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THE STORY OF COMMERCIALLY PURE IRON

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THE STORY OF COMMERCIALLY PURE IRON

—AND WHY IT RESISTS RUST

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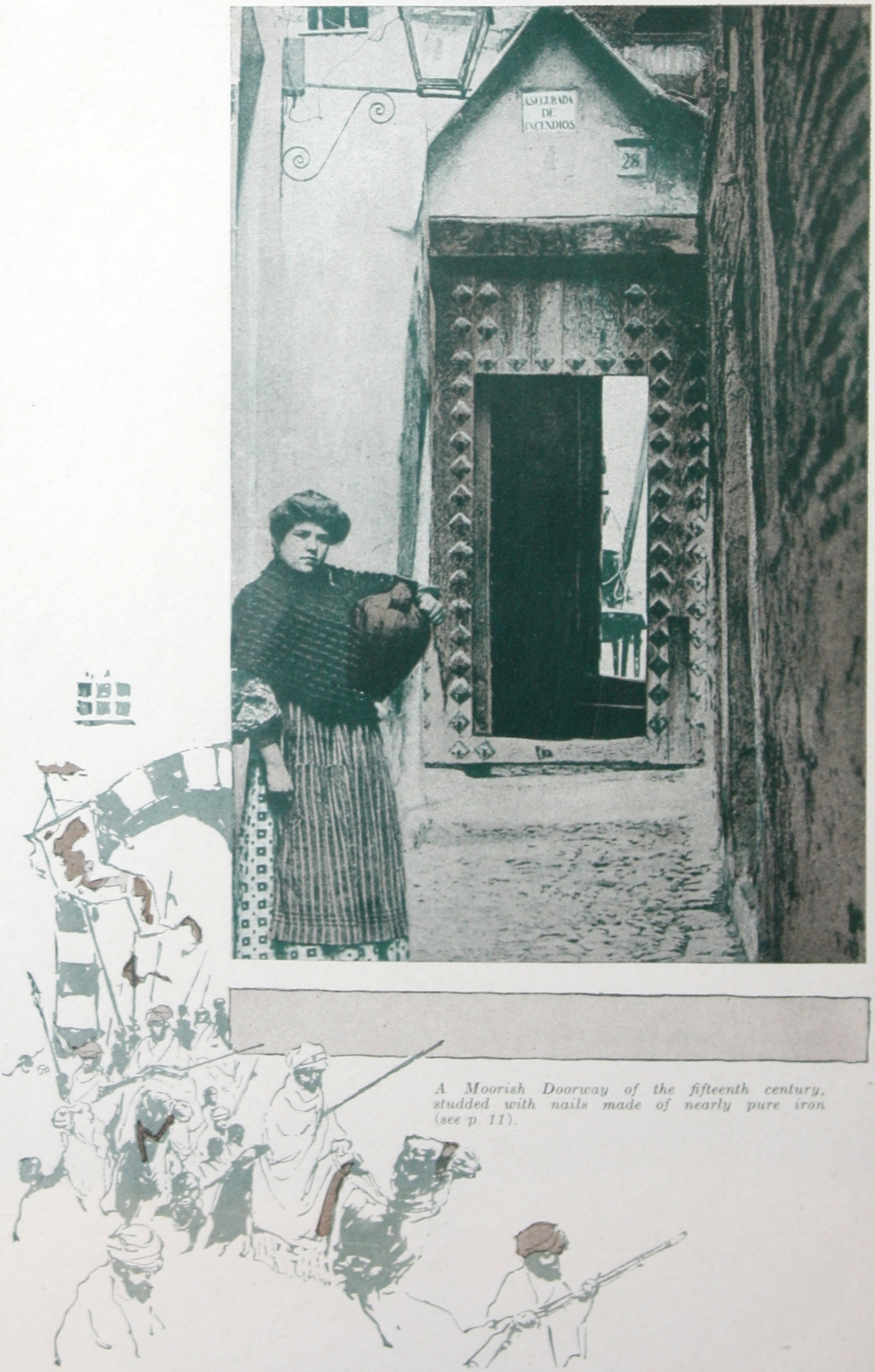


A Moorish Doorway of the fifteenth century, studded with nails made of nearly pure iron (see p. 11).

THE STORY OF COMMERCIALLY PURE IRON

ALL knowledge that we possess today has been gained by experiment. Sometimes the experiment was not purposely made, but was the result of accident. We know that the primitive races of men, before they had learned to smelt metals from their ores, fashioned tools and weapons from stone. Since flint was plentiful, and, because of its hardness, well suited for their purpose, this species of rock was widely used by artisans of the Stone Age. It requires no great stretch of the imagination to picture what probably happened when, in the process of shaping an arrow head or spear head, one piece of flint was struck violently against another. Sparks were produced, and starting from this accidental discovery, prehistoric man learned to kindle fires by striking sparks from flints. Having discovered a way to kindle fires at will, other discoveries followed. It is said that the art of making glass probably owes its origin to a fire kindled on a beach, the necessary ingredients for glass-making being provided by the silica of the sand and the metallic oxides contained in the rocks used for making a rude fire-place, which, fused by the fire, pointed the way to glass-making.

Doubtless the art of metal-working was discovered by primitive man in some such accidental way. If rocks containing an easily fused metal, like lead, or even copper, were used to fashion a fire-place, the heat of an ordinary wood fire, blown by the wind, would be sufficient to smelt the metal from the ore, and an observing savage, noting in the ashes of his fire these metallic nuggets, and finding that they could be easily shaped into useful articles by hammering, might be led to experiment with fire and rocks of various kinds until another secret of Nature was wrested from her.

When and how man's knowledge of metal-working was actually obtained we do not know, but it is certain that the working of copper and tin (two easily fused metals) preceded the working of iron, for the earliest known tools and weapons after the Stone Age are of bronze (an alloy of tin and copper), while centuries intervened before man learned to produce a fire hot enough to reduce iron from its ore, and other ages before he acquired the art of converting iron into steel.

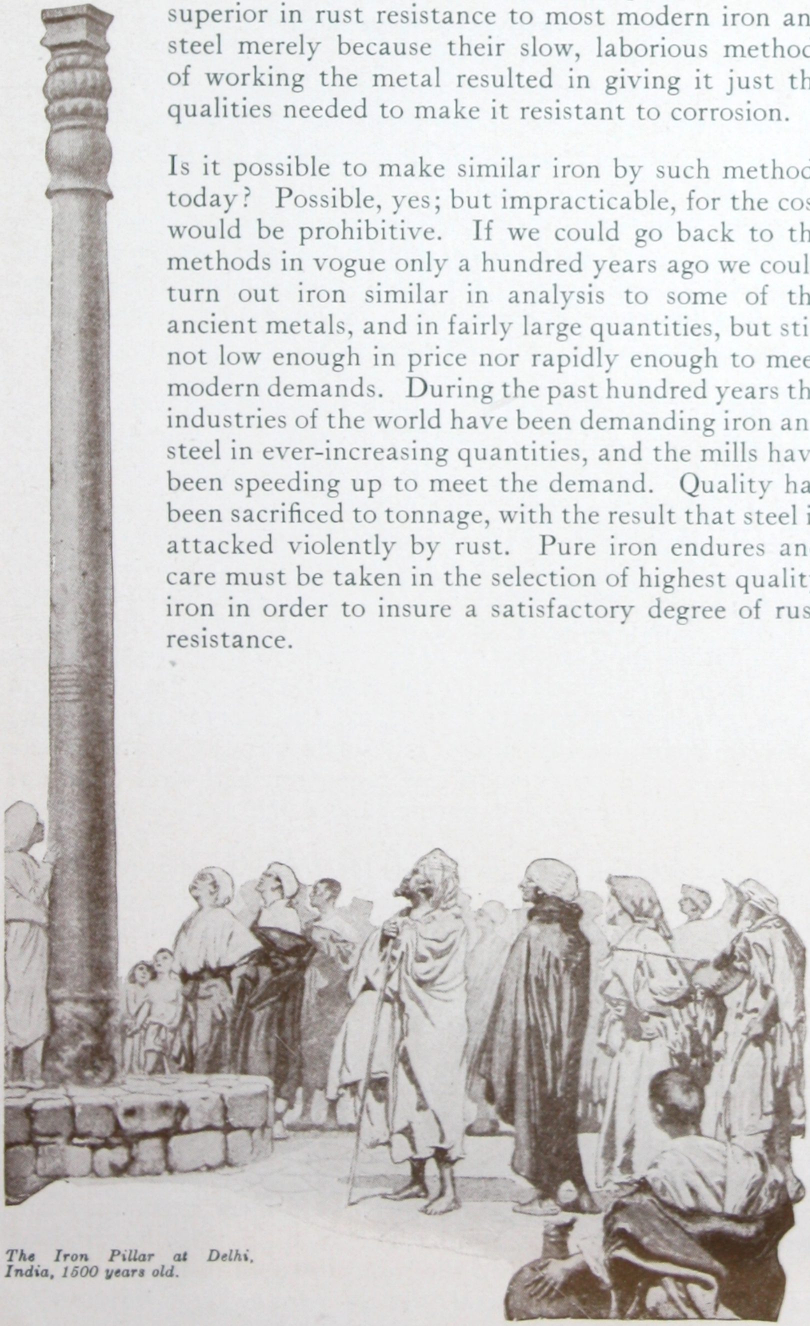
Crude as must have been the primitive iron furnace, the metal turned out was remarkable for its purity. There were reasons for this. In the first place, charcoal was used for fuel instead of coal or coke, and hence sulphur is always low in specimens of ancient iron. Secondly, all iron was made from virgin ores—there was no need of using scrap metal in the days when rich ore was plentiful and cheap and the demand for iron and steel small. The necessity of remelting scrap, which the huge modern demand for iron and steel brought about, was not felt by early iron-workers, and hence their product is low in copper and other impurities, which the use of scrap metal introduced.

Making iron in small quantities, a few pounds at a time, the early iron-workers were able to watch the process carefully. When they came to fashioning tools and weapons from the iron thus produced, the constant reheating of the metal necessary to keep it at a workable temperature and the long-continued hammering it received in shaping served to distribute the small percentage of impurities it still contained equally throughout the mass. In other words, ancient iron is usually remarkably free from impurities. Thus, without the knowledge of metallurgy we possess today, the

Primitive Furnace for Smelting Iron

ancient ironworkers turned out a product that is superior in rust resistance to most modern iron and steel merely because their slow, laborious methods of working the metal resulted in giving it just the qualities needed to make it resistant to corrosion.

Is it possible to make similar iron by such methods today? Possible, yes; but impracticable, for the cost would be prohibitive. If we could go back to the methods in vogue only a hundred years ago we could turn out iron similar in analysis to some of the ancient metals, and in fairly large quantities, but still not low enough in price nor rapidly enough to meet modern demands. During the past hundred years the industries of the world have been demanding iron and steel in ever-increasing quantities, and the mills have been speeding up to meet the demand. Quality has been sacrificed to tonnage, with the result that steel is attacked violently by rust. Pure iron endures and care must be taken in the selection of highest quality iron in order to insure a satisfactory degree of rust resistance.



The Iron Pillar at Delhi, India, 1500 years old.

The Demand For Increased Tonnage And How It Was Met

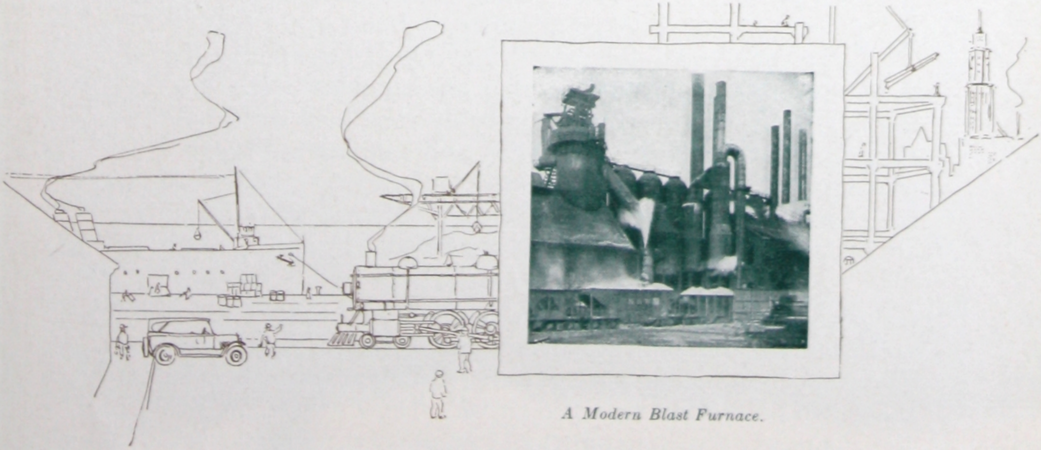
IRON and steel, the two metals most widely used today for industrial purposes, were employed only to a very limited extent 150 years ago. Let us go back in imagination to the period just before the American revolution and see to what uses iron and steel were put in those days. Tools, cutlery, weapons and nails; spades, picks, hoes, and plow shares; wagon tires and axles; chain and anchors, fish hooks and needles; window bars and door hinges—these were the principal articles in the manufacture of which iron and steel were used.

The steam engine was not yet invented. There were no railroads, no dynamos or electric motors, no telegraph or telephone wires and instruments, no wire fencing, no machine tools, no automobiles and tractors, no agricultural machinery, no canning industry. In the construction of ships and wheeled vehicles very little iron or steel was used. In building construction, bridges, culverts, sewers, and aqueducts, wood, brick and stone were employed. The cooking utensils were of earthenware or copper. Illuminating gas and electric lights were unknown, so there was no demand for iron or steel for the manufacture of gas mains and pipes, conduits or fixtures. In short, the market for iron and steel was so limited that almost any single industry in which these metals are used today consumes more iron and steel than was used in *all* the industries a century and a half ago.

When the demand for a product is limited, leisurely processes of manufacture are possible. Iron and steel were no exception to this rule. The ore was smelted in furnaces in which a hand bellows supplied the blast. Ore being plentiful, the demand for iron and steel small and prices high, only the best and purest ores were used. Low grade ores such as are employed today in the manufacture of some steel were rejected as unfit for use. These conditions resulted in the iron of former days being much freer from impurities than that turned out by the average furnace today.

But there are still other reasons why the articles manufactured by our forefathers from iron and steel were freer from impurities and more uniform in texture. The same leisurely methods of manufacture that produced the iron were used in fabricating the articles made of iron or steel. There were no huge furnaces for reheating the metal in immense quantities, no rolling mills or steam hammers. The iron was refined in small quantities, the articles manufactured were nearly all forged on an anvil by repeated blows of a hammer and were frequently reheated in the forge. The result of this continued hammering and reheating was that practically all of the impurities remaining in the iron were eliminated.

With the increase in demand for iron and steel which came in later years these slow but careful methods of manufacture were abandoned. The cry was now for quantity production—for tonnage. Industrial plants were demanding steam engines, and later electric generators and motors; railroads were demanding rails and locomotives and later steel cars; shipyards, abandoning the use of wood, were calling for plates of iron and steel to build steamships; engineers and contractors demanded structural shapes and bridge members. People were no longer content to carry their water from wells or light their homes with candles or oil lamps but demanded iron pipes for water and gas. The discovery that food products could be preserved by sterilizing them in metal containers led to an immense increase in the demand for tinned sheets; and so with each new invention the demand for iron and steel increased at the same time that the clearing away of the forests, in order that the land might be used for agricultural purposes, reduced the supply of wood and made it more expensive.



A Modern Blast Furnace.

To meet this yearly increasing demand for their product the makers of iron and steel were obliged to abandon their old, slow, painstaking methods of manufacture, that had given them a product of great purity but in limited amounts. Quality was now sacrificed for quantity. Tonnage increased by leaps and bounds, but the product was something very different from old-fashioned, hand-made iron.

It was a product chemically impure and structurally imperfect. Analysis showed it to contain carbon, sulphur, phosphorus, silicon, manganese and copper in amounts much greater than in the old-fashioned iron, together with such gaseous impurities as oxygen, hydrogen and nitrogen, while an examination of the texture of the metal showed it to be of different densities in different parts and to be honey-combed with blow-holes caused by the occluded gases, which, not having been given time to escape in the hasty process of manufacture, had remained in the steel, giving it a spongy texture.

With every industry clamoring for more iron and steel these defects were not noted at first, but what was noted very quickly was that this hastily made steel was rapidly consumed by rust, while old-fashioned iron was not.

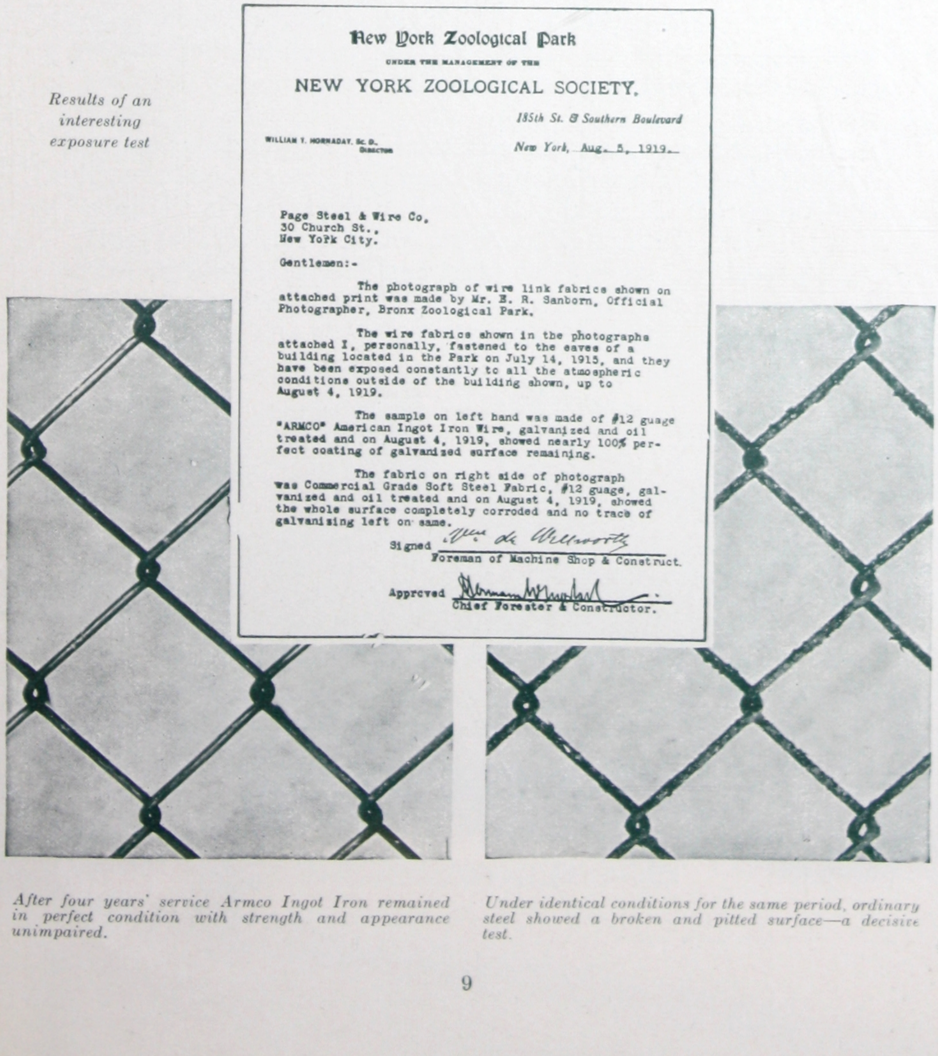
Impurities In Iron And Steel

GOLD, silver, copper and other metals are frequently found in large masses of great purity, but this is not true of iron. Oxygen and sulphur both have a strong affinity for iron and during the countless ages that the unmined metal has been in the ground it has become thoroughly combined with these two elements. Mixed with the oxygen and sulphur are found other elements which must be eliminated, or nearly so, before iron fit for commercial use can be produced. Among these impurities are manganese, phosphorus, silicon, carbon.

Oxygen and nitrogen are gases which not only envelop the whole earth but are diffused throughout the universe. Mixed in about the proportion of one part of oxygen to four parts of nitrogen, these two gases constitute the air we breathe; while the water of the rivers and the sea consist of one part of oxygen combined with two of hydrogen. Nitrogen and hydrogen, though not found in the original iron ore, find their way into the product during the manufacturing process, unless extraordinary precaution is taken to eliminate them.

Manganese is a metal which resembles iron in many ways. It is extremely hard and brittle and oxidizes rapidly on exposure to the air.

Sulphur and phosphorus compounds are always found in iron ores; both are objectionable.



Results of an interesting exposure test

New York Zoological Park
UNDER THE MANAGEMENT OF THE
NEW YORK ZOOLOGICAL SOCIETY.
185th St. & Southern Boulevard
WILLIAM T. HORNADAY, Sc. D.,
DIRECTOR

New York, Aug. 5, 1919.

Page Steel & Wire Co.
30 Church St.,
New YoPk City.

Gentlemen:-

The photograph of wire link fabrics shown on attached print was made by Mr. E. R. Sanborn, Official Photographer, Bronx Zoological Park.

The wire fabrics shown in the photographs attached I, personally, fastened to the eaves of a building located in the Park on July 14, 1915, and they have been exposed constantly to all the atmospheric conditions outside of the building shown, up to August 4, 1919.

The sample on left hand was made of #12 guage "ARMCO" American Ingot Iron Wire, galvanized and oil treated and on August 4, 1919, showed nearly 100% perfect coating of galvanized surface remaining.

The fabric on right side of photograph was Commercial Grade Soft Steel Fabric, #12 guage, galvanized and oil treated and on August 4, 1919, showed the whole surface completely corroded and no trace of galvanising left on same.

Signed
Foreman of Machine Shop & Construct.

Approved
Chief Forester & Constructor.

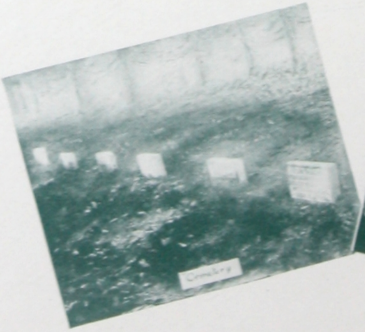
After four years' service Armco Ingot Iron remained in perfect condition with strength and appearance unimpaired.

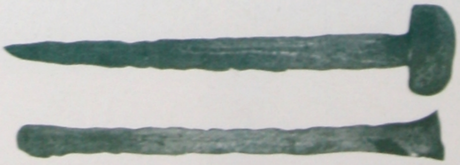
Under identical conditions for the same period, ordinary steel showed a broken and pitted surface—a decisive test.

Silicon is an element which in nature is always found combined with oxygen, with which it forms silica, or sand, or in larger masses rocks, such as quartz. Silicon must be eliminated from iron as it is electro negative to this metal and increases the rate of corrosion.

Carbon is not usually found in ore but the coke used in smelting the ore is almost pure carbon and combines with the metal in the blast furnace, so that all pig iron contains carbon. For some purposes, as for instance in tool steel which must be intensely hard in order to hold its cutting edge, carbon is a desirable ingredient, but it is well known that a steel containing a large percentage of carbon will rust rapidly, while an iron containing a low carbon content will not. The dividing line between iron and steel depends, in fact, largely on the percentage of alloying elements the metal contains.

In the special open-hearth process used in the manufacture of ARMCO Ingot Iron the impurities named above are so thoroughly eliminated that the total of all of them remaining in the iron—that is to say, the total sulphur, phosphorus, carbon, manganese, silicon, copper, oxygen, hydrogen and nitrogen contents—does not exceed 16 one-hundredths of one percent, or approximately one-sixth of one percent.





Iron nails taken from the grave of a soldier after being buried for 100 years in Mt. Hill Cemetery, Eaton, Ohio.

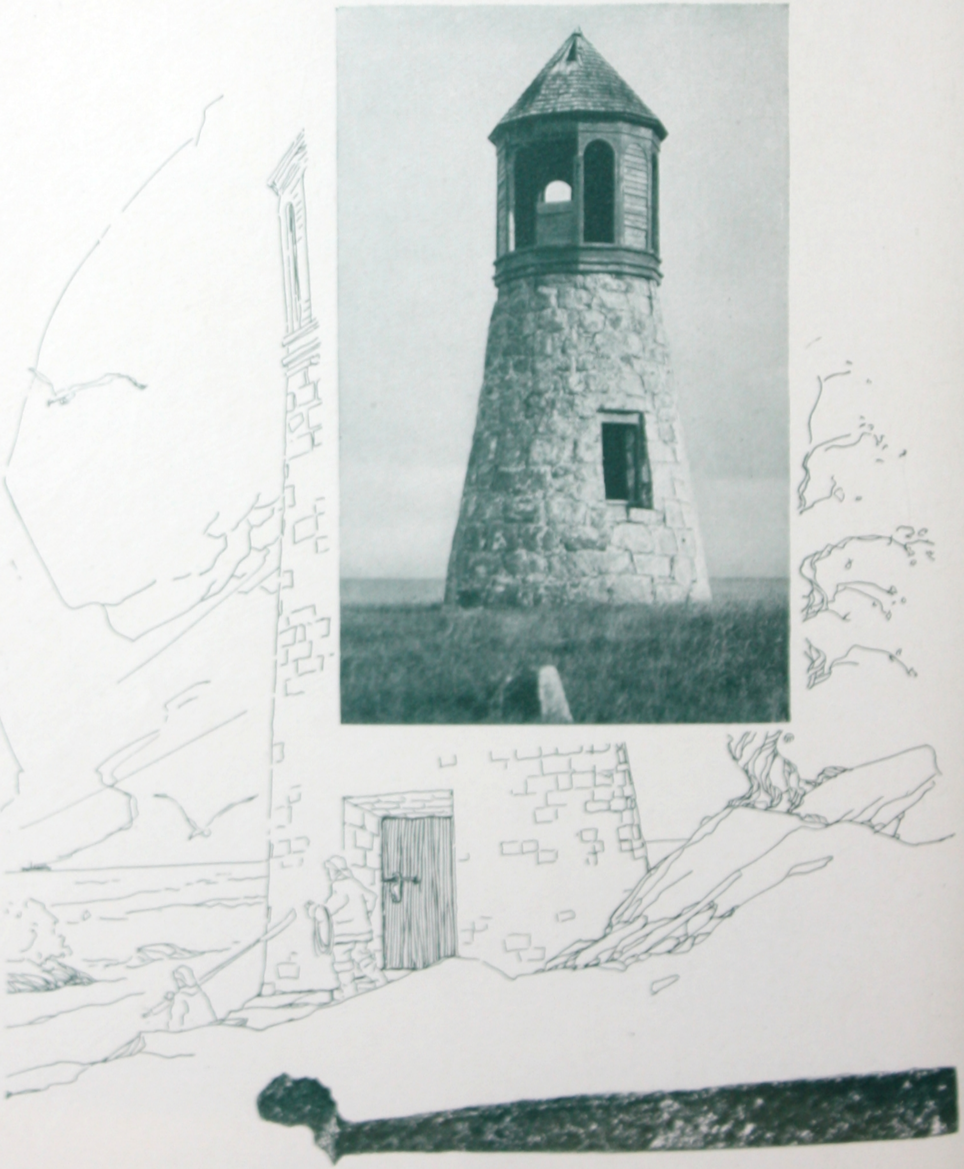
The Search for the Cause of Rust

IN the United States it was the Department of Agriculture that first undertook a systematic investigation to discover the cause of rust in iron and steel. This was begun in 1905 and was due to loud and ever-increasing complaints from the farmers that their wire fences, agricultural machinery, and corrugated roofing and siding were being destroyed by rust so rapidly that the expense of replacing them had become a burden too heavy to be longer endured.

Many of these farmers in the New England States, and in other long-settled sections of the country, lived in farm houses that had been erected in the previous century and in which the nails of old-fashioned, hand-wrought iron were still in good condition. At Mount Hill Cemetery, Eaton, Ohio, there was exhumed in 1892 the body of a solidier who had been buried in 1792 and the iron nails in his coffin were found to be unharmed by rust after being in the ground 100 years. Telegraph wire made of old-fashioned iron was found to be uninjured by rust after more than 60 years' exposure to the elements, while the farmers complained that their modern wire fencing was destroyed by rust in four or five years.

In Florida the ruins of Old St. Joseph gave up their story of the ability of commercially pure iron to endure. There in '43 a cyclone completed the devastation plague had started—the wilderness closed again over the ruins of a thriving city. But a year or two ago workmen unearthed an historic iron rail, formerly a part of the old St. Joseph and Iola Railroad. After eighty years exposure in this moist climate, the rail is still practically unrusted. Scientists examining the rail found it to be practically pure iron, again showing that pure iron endures.

Europe and Asia contributed even more impressive examples of the rust-resisting qualities of old-fashioned iron. In a Moorish house in Spain, built about the time Columbus sailed on his first



Photograph of historic Lighthouse off Cape Cod, Mass., erected in 1816. The iron latch shown below was exposed to the salt-laden moisture for over fifty years, and has formed only a surface film of rust.

voyage of discovery, is a door heavily studded with wrought iron nails which after the lapse of four centuries, are uninjured by rust. Near the city of Delhi, in India, is a monument consisting of a column of wrought iron that was erected fifteen hundred years ago. It is still in as perfect condition as if it had been exposed to the weather for but a single year.

With these examples before them to prove that it was possible to make a rust-resisting iron the question the chemists and metallurgists had to solve was: Wherein does this old, rust-resisting iron differ from modern, quick-rusting iron and steel?

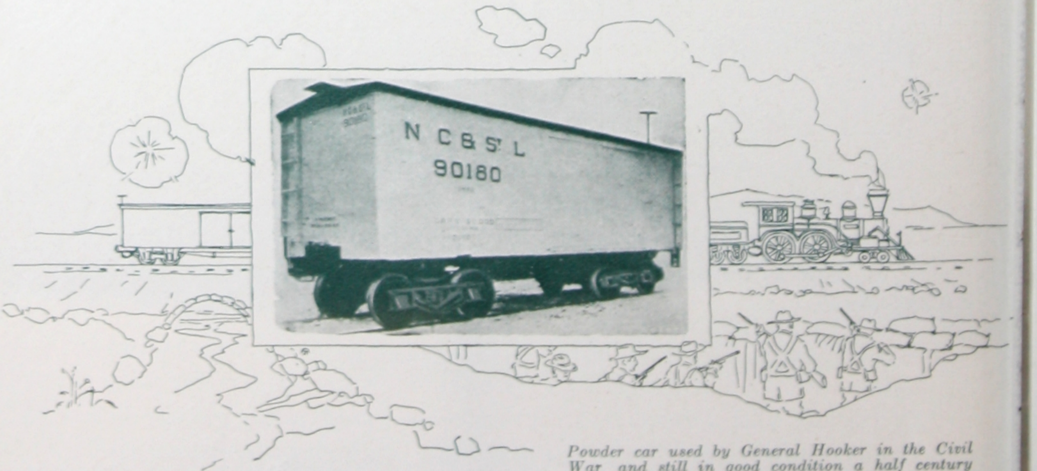
Chemical analysis and microscopic examination gave the answer. The old-fashioned, rust-resisting iron when analyzed was found to be exceedingly free from impurities, while modern, quick-rusting steel was found to contain an appreciable amount of such impurities as carbon, sulphur, phosphorus, silicon, manganese, together with the gaseous elements oxygen, nitrogen and hydrogen. Sometimes one impurity predominated, sometimes another. In the installations of iron that have endured for generations and for centuries the impurities were more nearly eliminated than in modern, quick-rusting steel found on the market today. Hence, reducing the results of their investigations to a single sentence, the chemists said: "The purer the iron the longer it lasts."

But the scientists who had been examining these samples of metal with high-powered microscopes were yet to be heard from. To the naked eye a bit of iron or steel appears to be composed of the same material throughout, but viewed under the microscope it is seen to be a conglomerate of materials differing in texture and appearance. Moreover, the microscope brings to light minute imperfections in the structure of the metal, such as fissures and orifices, that are not visible to the unaided eye. These differences in texture and defects in structure were found to be greater in extent and of more frequent occurrence in modern quick-rusting steel than in old-fashioned, rust-resisting iron. Hence the conclusion arrived at by the microscopists was that uniformity of texture and freedom from imperfections tend to prolong the life of iron and steel.

The many investigations, experiments and tests made since these facts were discovered have served to confirm them. It is now the generally accepted opinion that the chemical change in iron or steel, that is known as oxidation, corrosion or rust, proceeds more rapidly and with more destructive effect in metals that are contaminated with impurities than in relatively pure metals; and, further, that as between metals of equal purity the rust-resisting qualities will be greater in the metal that is most uniform in texture and freest from structural defects.

Science had now answered the question: What causes rust? But a more puzzling problem now presented itself for solution.

Granted that impurities in steel, lack of uniformity in texture, and the presence of structural defects do cause rust, the question is: How do they cause it? Why should these things cause the atoms of iron to unite more readily with the oxygen that is present in air and water, thus forming the red oxide of iron that is commonly known as rust? This brings us to one of the most important discoveries in electro-chemistry.



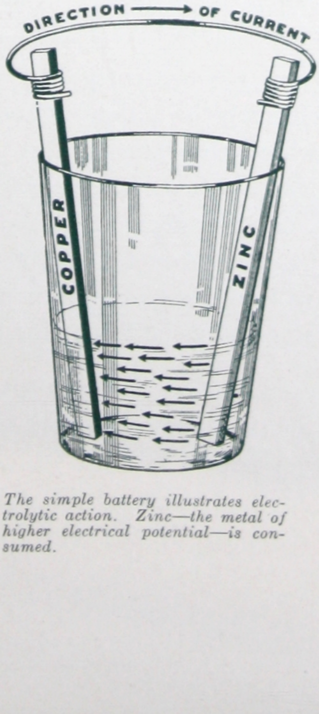
Powder car used by General Hooker in the Civil War and still in good condition a half century later. Made of old fashioned iron of a high degree of purity.

The Electrolytic Nature of Rust

A DIFFERENCE of "head" in liquids causes the fluid to flow from the higher to the lower level. A difference in temperature causes a similar result. And there is still a third cause that can produce motion in the atoms constituting a body—a difference in "electric potential." "Potential" means a difference in electrical level just as "head" means a difference in water level. All metals possess different electric potentials, some standing at higher and some at lower levels. Electro-chemists have classified the various elements in accordance with their "potential difference" and in such a table iron occupies the fifteenth place from the top or "positive" end of the scale, and copper the twenty-fourth place. The electric potential (or "head") of iron is, therefore, higher than that of copper—"iron is electro-positive to copper and copper electro-negative to iron." Zinc is higher in the electric potential scale than either iron or copper and consequently is electro-positive to both of them.

If you take a glass tumbler and place in it two strips of metal, one of copper and one of zinc, taking care that they are so placed that they do not touch one another, and if you now connect their upper ends with a wire and cover their lower ends with water in which common salt has been dissolved (or, better still, water containing a small amount of sulphuric acid) you will have an electric battery similar to that invented by the Italian scientist, Volta, more than a century ago.

In such a battery the current in the wire flows from the copper to the zinc plate, but you will see by looking at the illustration that in order to complete the circuit it is necessary for the current to flow through the water contained in the glass from zinc to copper. The zinc is known as the "positive" plate or "anode;" the copper as the "negative" plate or "cathode;" while the water containing salt or sulphuric acid is called the "electrolyte."



The simple battery illustrates electrolytic action. Zinc—the metal of higher electrical potential—is consumed.

When the upper ends, or "poles," of the two strips of metal are connected by a wire as shown in illustration the effect of the current will be visible in the multitude of tiny bubbles that form in the neighborhood of the copper, or negative, plate. These bubbles are caused by the liberation of hydrogen gas from the water. If you break the circuit, disconnecting the wire from one of the strips of metal, the bubbles disappear, but they will be observed again as soon as the circuit is re-established.

If you leave the battery for several days with the wire attached to the upper ends of the two strips of metal you will note that the zinc, or positive plate, has wasted away, and it is well to remember here that wherever there is electrolytic action between two metals it is always the positive metal—the metal of higher electric potential—that is destroyed.

Even if you disconnect the wire but leave the two metals immersed in the electrolyte the zinc will still waste away, but more slowly. This is explained by the fact that commercial zinc is not absolutely pure. The impurities form with the particles of pure zinc miniature batteries in which the particles of pure zinc constitute the positive plates and the impurities the negative plates. (See article BATTERY, Encyclopedia Britannica, 11th edition, Vol. III, page 532.) It will be well to remember this fact because we shall see presently how impurities in steel give rise to similar electrolytic action between themselves and the pure metal in which the latter, being electrically positive to the impurities, wastes away like the zinc in the battery we have been studying. The two metal strips in a battery do not have to be zinc and copper. Any two metals will do, though the current generated will not be so strong if the difference in electric potential is not so great as between zinc and copper.

And now let us see how the various elements stand in relation to one another when arranged in a series in which each element is positive to all that follow it and negative to all that precede it. At the bottom of this series, electrically negative to all the other elements, is our old friend, oxygen. In the electro-chemical series of the elements printed on this page, note that iron is positive to most of the impurities usually found in carelessly made steel, which means that in any electrolytic action set up between the particles of pure iron and the impurities, it will be the iron that wastes away. Note also that zinc stands higher in the series than iron and is therefore positive to it, hence in electrolytic action between iron and zinc it is the zinc that wastes away. This

Caesium Rubidium Potassium Sodium Lithium
Barium Strontium Calcium Magnesium Aluminum
Chromium Manganese

ZINC

Gallium

IRON

Cobalt Nickel Thallium Indium
Lead Cadmium Tin Bismuth

COPPER

HYDROGEN

Mercury Silver Antimony Tillurium Palladium
Gold Iridium Rhodium Platinum Osmium

SILICON

CARBON

Boron

NITROGEN

Arsenic Selenium

PHOSPHORUS

SULPHUR

Iodine Bromine Chlorine

OXYGEN

The Electro-Chemical Series of Elements.

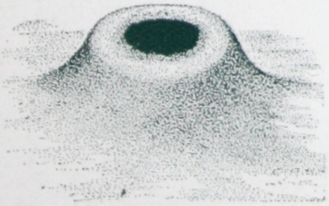
explains why zinc is a good protector of iron—it preserves the latter by sacrificing itself.

We are now prepared to grasp what happens when iron or steel containing comparatively large percentages of impurities is exposed to moisture which, both in the air and in the ground, is always found to contain some of those salts or acids that, when combined with water, stimulate the electrolytic action between metals of different potentials. The molecules of iron are of higher potential than most of the impurities found in commercial steel, hence they are attracted to the areas of lower potential—the areas occupied by the impurities. FERRIC HYDROXIDE is the name of the resulting product. This indicates that iron, hydrogen and oxygen are now combined; and it is this combination of all three elements that is attracted to the areas of lower potential, the association of the oxygen with the iron having changed the latter, meanwhile, from its metallic state into the red oxide of iron that we call rust.

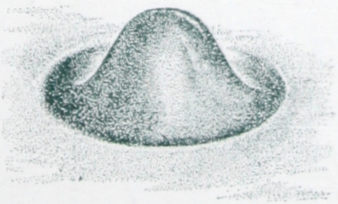
Thus particles of rust are deposited on the areas occupied by the impurities, and, as this process continues, molecule after molecule of the pure iron is drawn to the centers of attraction until finally one may observe with the naked eye that pits have been formed in some places and little mounds of red rust in others. The pits (which eventually become holes) mark the spots from which the manganese of the steel has been excavated (if we may use the term) and the mounds the spots where it has been deposited in the form of rust. This description applies to the rapidly destructive form of corrosion, or "tubercular rust" as it is called, that is characteristic of impure iron and steel. There is another form of corrosion, observed in the purer metals, in which the surface is covered with an even, closely adherent film of rust and then for some reason—not clearly understood as yet, but probably owing to the fact that such impurities as the metal contains are evenly distributed instead of being segregated as in the case of rapidly rusting steel—the rusting process is arrested and the metal remains in the same state for years.

In a bulletin on "The Corrosion of Iron," published by the U. S. Department of Agriculture, Bureau of Public Roads, Dr. Allerton S. Cushman illustrates by means of two simple diagrams what occurs when iron or steel is subjected to electrolytic action, if the impurities are segregated instead of being equally distributed. In such a case, he says, we may have either a positive center (high electric potential) surrounded by a negative area (low electric potential); or we may have a negative center surrounded by a positive area. These two possible conditions are illustrated in the diagram below.

Continuing, he says that in the first case we would expect to find the positive atoms of metal in the center attracted to the negative area surrounding them which would result in a crater-like formation (an elevated ring of rust with a depression in the center); while in the second case the positive atoms would be drawn inward to the negative center, resulting in a solid cone of rust surrounded by a circular depression. Represented pictorially the two accumulations of rust would look like this:



Crater formation with pitting effect in center.



Cone formation with pitting effect in surrounding area.

As a matter of fact these two formations can be clearly distinguished when patches of rust are viewed under a microscope. Here, then, it would seem we have the true explanation of why a pure metal of homogeneous texture is less subject to corrosion than an impure metal in which the impurities are segregated. The smaller the percentage of impurities and the more equally they are distributed throughout the metal, the feebler will be those internal electric currents which, flowing from areas of higher potential to areas of lower potential, cause the molecules of pure metal to migrate to those centers of attraction where the impurities are congregated.

The Development of Armco Ingot Iron

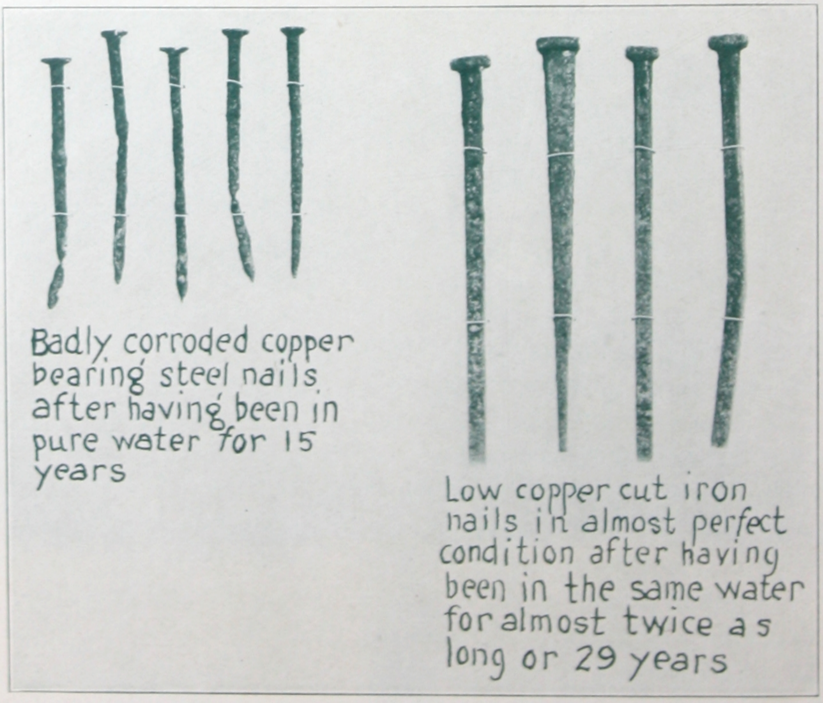
LET us review for a moment the outstanding facts so far discussed in the Story of Pure Iron—

First—that early specimens of iron have endured the corroding influences of centuries and have come down to the present era in almost perfect condition.

Second—that modern steel or ordinary iron—made without adequate regard to purity and evenness of texture, rusts rapidly and so results in an enormous yearly waste.

Third—that scientific investigation has clearly shown corrosion to be hastened by the presence of impurities.

What was the logical answer?—to produce by modern methods an iron which would parallel in analysis the historic specimens of long lasting metal.


Badly corroded copper bearing steel nails after having been in pure water for 15 years
Low copper cut iron nails in almost perfect condition after having been in the same water for almost twice as long or 29 years

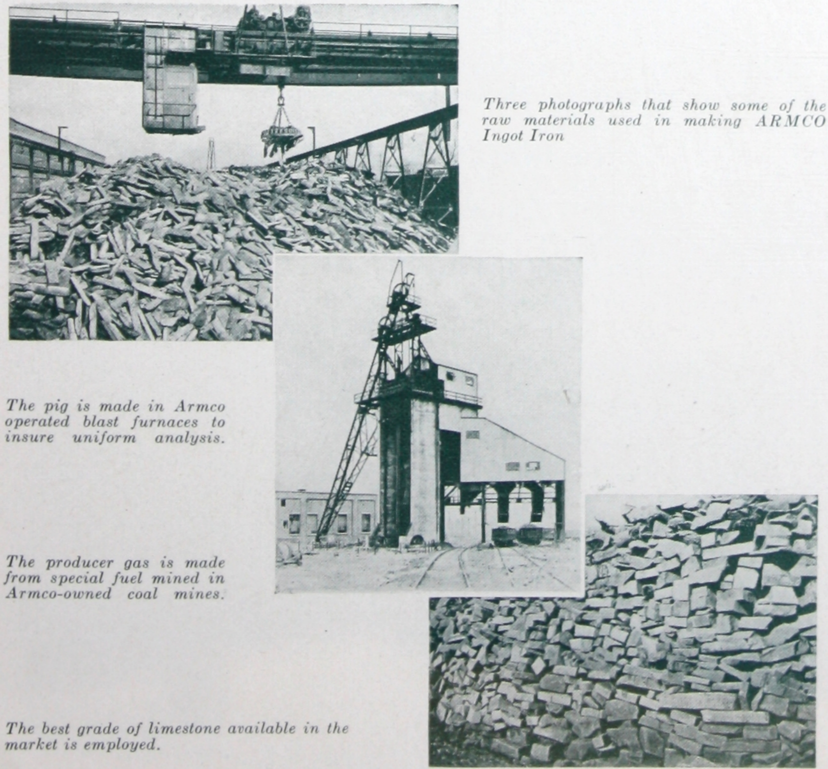
Twenty years ago no such metal was made on a commercial scale. Ordinary steel and iron were far from answering the exacting requirements of a rust-resisting material.

It was necessary to develop an entirely new commercial metal—made by entirely new processes.

A group of metallurgists and engineers in Ohio, after years of painstaking experiments, finally produced such a metal—ARMCO Ingot Iron.

Precautions Observed

Each step in the making of ARMCO Ingot Iron involves special precautions and special processes. To begin with, in order to attain the highest degree of purity in the finished metal it is necessary that the raw material be carefully selected. To insure the purity of ARMCO Ingot Iron the American Rolling Mill Company maintains its own blast furnaces at Columbus, Ohio, and Ashland, Kentucky, where pig iron low in impurities is turned out. This pig iron of its own manufacture, as well as all material purchased from outside sources, is subjected to rigid analysis and



Three photographs that show some of the raw materials used in making ARMCO Ingot Iron

The pig is made in Armco operated blast furnaces to insure uniform analysis.

The producer gas is made from special fuel mined in Armco-owned coal mines.

The best grade of limestone available in the market is employed.

any material that fails to measure up to a high standard of purity is rejected. In the manufacture of ordinary steel such scrupulous precautions are not usually observed in the selection of raw material.

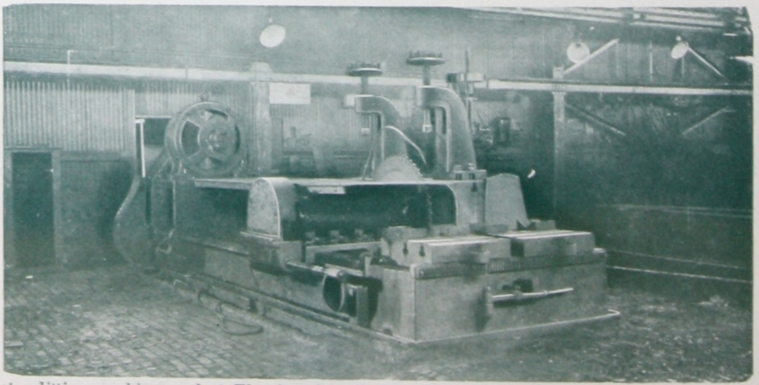
Open hearth furnaces are used for melting the metal in the manufacture of ARMCO Ingot Iron. On account of the higher temperatures and longer heating required these furnaces must be lined with special material and the linings must be rebuilt more often than in the usual open hearth furnace.

In these furnaces provision is made for accurate regulation of temperature, and not only is each heat carefully watched by experienced men, but samples of the molten metal are taken from time to time and analyzed before the material is teemed into ingots. Nothing is left to guesswork or chance. Each step in the process of manufacture is checked by metallurgical experts provided with the most modern laboratory equipment.

The treatment of the metal while in the furnace and when being poured, careful observation of its action in the molds, a sharp outlook for piped or burned ingots, painstaking precautions for the elimination of occluded gases, all have an important bearing on the purity and even texture of the finished sheet, and hence on its rust-resisting qualities.

The Ingot Splitting Machine

The watchful supervision, which begins with the selection of raw material and continues while the metal is in the furnace, is not suffered to relax when the iron is teemed into ingots. Samples of the ingots are analyzed, but since laboratory tests cannot always be relied upon to disclose the presence of occluded gases,



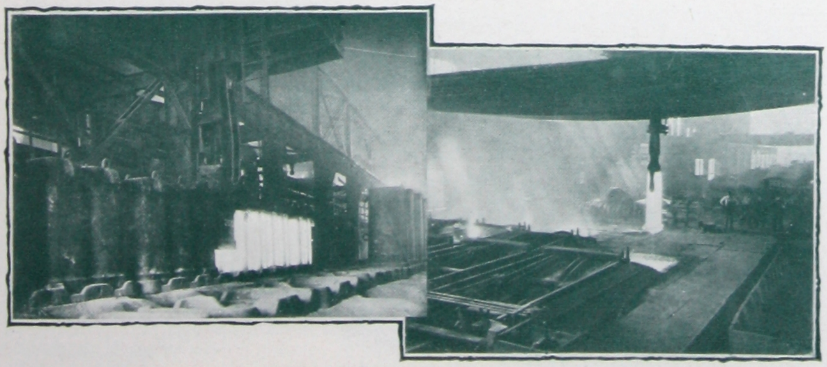
Ingot splitting machine used at The American Rolling Mills for the investigation of heats suspected of being unsound.

which may not be present in the sample taken and yet may exist deep down in the interior of the ingot, a unique precaution is taken to insure perfection of physical structure. From time to time sample ingots are divided lengthwise through the middle on a special ingot splitting machine which lays the interior of the ingot open to view. If occluded gases have not been reduced to the allowable minimum this will at once be evident by the spongy, porous structure of the ingot.

Such defects in the physical structure of the ingot are important, for sheets rolled from spongy ingots will contain blisters, and although these may be concealed in the finished sheet by the galvanized coating they will inevitably lead to rapid corrosion. At this point in the manufacture of ARMCO Ingot Iron, as at every previous and subsequent point, the purity and density of the metal must be proved or it is not allowed to pass. So far as is known, The American Rolling Mill Company is the only producer of sheet iron or steel that subjects its ingots to the severe test of an ingot splitting machine.

Safeguarding the Ingot in the Soaking Pit

Experience has demonstrated that a frequent source of defective sheets is the overheating of the ingots in the soaking pit. To one not experienced in mill practice it may seem strange to assert that iron can be overheated, but such is the case. The structure of the metal is profoundly affected by the temperature to which it is subjected and while it is desirable to soften the ingot in the soaking pit as much as possible so that it may be in just the proper



The white hot metal is now ready for the soaking pit.

Lifting Ingot out of soaking pit. In a few minutes it will be rolled into blooms and later into sheet bars.

condition for rolling, the greatest care must be exercised to guard against overheating.

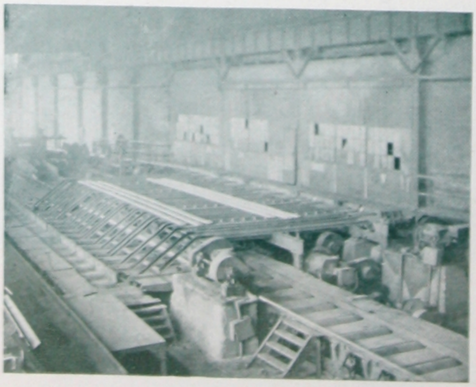
In the Soaking Pit Department of The American Rolling Mill Company the employees are all men of long experience and demonstrated skill, and the regulation of the heat treatment has been reduced to scientific exactness. It is also worthy of notice that ARMCO Ingot Iron can be worked at higher temperatures than steel without endangering its quality. This fact in itself lessens the chances of the ingots being overheated.

Heat being favorable to chemical combination, oxides of iron in the form of scale are formed on the ingots in the soaking pits, and this scale must be eliminated, since if permitted to remain it would be rolled into the metal where it would act as any other impurity does, stimulating corrosion.

How Blooms and Bars are Inspected

THE Ingot is now ready to be rolled into blooms and sheet bars. It should be noted here that the ingot itself is not rolled into sheets but into large slabs called "blooms" which are afterwards rolled into "bars." It is from these smaller bars that the sheets are rolled, and at the bar shears also stand experienced men who watch for defects in the metal and throw aside any bar containing them. A triple check is maintained on the perfection of the metal from which the sheets are rolled, first when the blooms are cropped before being rolled into long bars, second, when the blooms are on the cooling bed, and third when the long bars are sheared into short bars.

The men at the bar shears also keep a sharp lookout for defects known as "seams," "laps," "scab," etc., which sometimes develop in the metal in the process of rolling the ingot into blooms. Because of their long experience in this kind of work, these men can detect at a glance defects that would not be noticeable to a less practiced eye and any bar that shows the slightest defect goes instantly to the scrap pile.

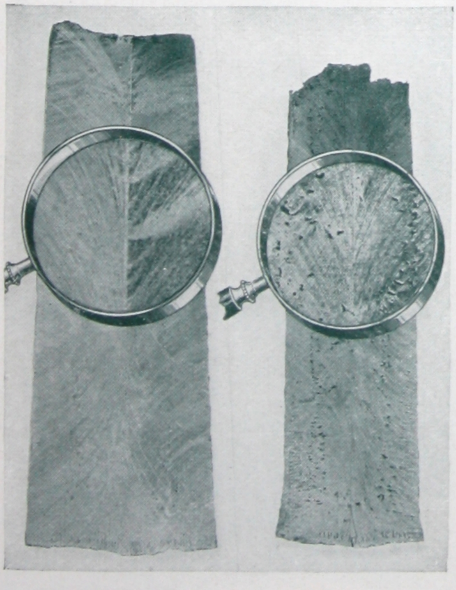


Pure Iron can be rolled only within a narrow range of temperatures. The blooms must be allowed to cool through the "critical range," on these racks before further working is possible.

Rust Often Caused by Slight Defects

IT should be remembered that the defects mentioned, and others that may affect the quality of the finished product, would be scarcely visible after the bars are rolled into black sheets, and would be impossible of detection after the sheets are galvanized. The purchaser of carelessly made sheet iron or steel, or of products made from them, has therefore no way of knowing that such sheets are defective until they fail in service. Hence the importance of looking for the ARMCO Ingot Iron trademark on all sheets or products purchased, for that trademark means that all the precautions heretofore mentioned have been taken to avoid imperfections.

It is common experience that very slight defects in a galvanized sheet will frequently cause rapid corrosion. You have probably often seen a sheet with a hole rusted through it in one spot though showing no signs of deterioration elsewhere. Sometimes in such cases the galvanizing will be perfect right up to the point of puncture. This form of failure is due to a defect in the sheet which, if it could be traced back, would probably be found to have had its origin in a defect in the ingot or in the bar from which the sheet was rolled. Galvanizing will protect a dense, pure homogeneous metal free from physical defects, and give it long life.



ARMCO INGOT IRON STEEL

Showing the completeness of the degasification in Armco Ingot Iron, compared with ordinary steel,—as indicated by the blow-holes under the magnifying glass.

A bubble of gas imprisoned in the metal, or a tiny bit of scale rolled into the surface of the sheet but concealed by the galvanizing, is sufficient to cause destructive corrosion when the sheet is exposed to the weather, or in the case of culverts, to the moisture and acids and alkalis of the soil.

Re-heating, Rolling and Annealing

After the ingots have been rolled into blooms and the blooms rolled into sheet bars, the latter are reheated in furnaces before rolling, and here again there are dangers to be guarded against, for if the temperature is not carefully watched and controlled, changes in the iron will occur that will be injurious to the finished sheet. If not heated sufficiently the metal will not be soft enough to permit of its being properly rolled. At the American Rolling Mill the reheating of the sheet bars and the subsequent annealing of the rolled sheets, which relieves the stresses caused by the rolling and insures a uniform temper throughout the sheet, are under the supervision of experienced men specially trained in this important work and aided by pryrometers which accurately indicate the slightest variation in temperature.

View in the Sheet Rolling Department. Furnaces in which the Sheet Bars are heated on the left. Rolls on the right.

ARMCO workman at the rolls

The Annealing Ovens. Here the sheets are subjected to high temperatures for several days in order that internal stresses due to rolling may be relieved.

The Zinc Coating

WE now come to the important subject of the protective coating which is usually given to ferrous metals for its further protection from corrosion.

Galvanized iron was invented almost two centuries ago. The original process was to give the metal a coat of tin and then dip it into molten zinc (spelter). The sheets were called "galvanized iron" though this name is now being changed to "zinc coated" or "zinced" sheets.

Today, the zinc coating process is carried on somewhat differently. The sheets of ferrous metal are first thoroughly washed in acid and water to remove all trace of grease and scale. They are not coated with tin, but are drawn through a pan of molten zinc and passed through rollers on emerging, which regulate the thickness of the coat.

After the sheets emerge from the bath, they take on the characteristic spangle, or crystalline appearance as the zinc cools. The sheets are then leveled, cooled, and inspected, any defective sheets being carefully separated from those that are perfect.

Variations in the Quality of Zinc Coated Sheets

Purchasers of galvanized sheets, or products made of this material, often have the idea that the lasting qualities of the metal depend purely upon the zinc coat, and that one zinced sheet is as good as another. This is far from true.

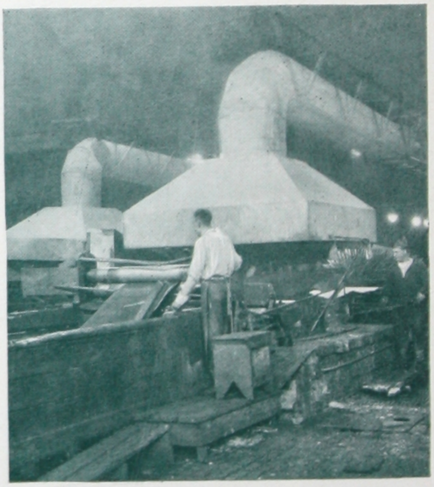
Several factors influence the qualities of zinc coated sheet metal. First, the temperature of the zinc bath must be standardized and carefully regulated. Otherwise the zinc will discolor and lack durability.

The quality of the base metal used is highly important. A dense, highly pure iron, comparatively free of gases, galvanizes much better than a less pure iron or steel in which other elements are found.

This is largely because of the fact that steels and impure irons dissolve to quite an extent in the zinc bath, forming an alloy which fails to make such a lasting coat as purer zinc. By test, it has been found that steel dissolves several times more rapidly than ARMCO Ingot Iron in hot spelter.

It is easy to see why impurities in the base metal and the zinc shorten the life of the coating. Zinc is electro-positive to iron, (See P. 15) and tends to protect the base metal by sacrificing itself when electrolytic action takes place.

Copper, carbon, silicon, in fact, most of the elements found in many irons and steels are decidedly electro-negative to iron and still more so to zinc. Thus these elements form negative poles for battery action, and tend to destroy the zinc coat by electrolytic corrosion.



The Galvanizing Pots.

This action takes place quite rapidly when the impure iron beneath the zinc is exposed to air and moisture by cracking, scratching, or by the formation of pin holes and blisters in the zinc coat by gases which may be in the base metal. These are the causes of "spot rusting" of galvanized sheets which so often destroy galvanized sheet products.

Service tests show this spot rusting can best be prevented by placing a comparatively pure coat of zinc on a highly pure, dense base metal—ARMCO Ingot Iron. Thus, even the protective coat lasts longer on this purer, more uniform metal.

Why Ingot Iron Makes Better Enamel Ware

The gleaming white enameled table top or stove panel you admire is made by fusing a kind of porcelain on sheet metal. This porcelain enamel is essentially a mixture of certain sands and clays carefully prepared by skilled workmen.

To make table tops, a sheet of metal already formed into that shape is dipped or sprayed with a sand and clay mixture. Then it is put in a very hot furnace where the mixture melts and fuses on the sheet.

Two properties of ARMCO Ingot Iron have led to its choice by leading porcelain enamelers all over the country. The first is its freedom from imprisoned gases; the second is its uniformity.

Under the intense heat of the enameling furnace, gases imprisoned in steel are liberated, forming blisters and pinholes. These ruin the finish of the porcelain enamel, and lead to rust of the metal underneath. From Ingot Iron these gases have been practically eliminated. The result is fewer rejections by the manufacturers and a higher quality product.

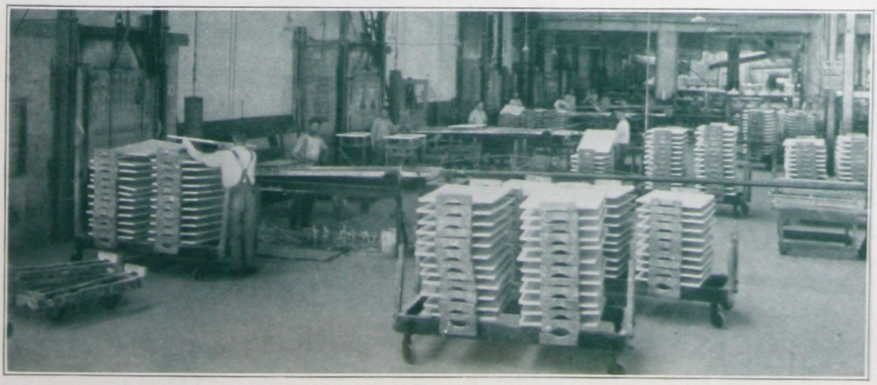
Furthermore, when the enameler has decided on a particular mixture for his porcelain enamel, when he has standardized on a certain temperature for his furnace, and a certain length of time for the enameling process, the uniformity of Ingot Iron enables him to secure satisfactory results day after day and week after week. He can standardize his practice with full knowledge that he will have a product of uniformly high quality.

To the consumer this is important because porcelain enamel on ARMCO Ingot Iron has a deep rich lustre. It has the finish which has produced the gleaming, spotlessly white kitchen of to-day. It has the durability which makes its beauty practical.

Why Coat Armco Ingot Iron?

The question is sometimes raised — "If this Ingot Iron is so superior, why do you coat it?"

Ingot Iron is not rust-proof. It lasts longer than ordinary steel in the same way that a cedar or a redwood fence post lasts longer than one of pine or hemlock. And, just as the service life of a cedar or redwood post is greatly prolonged by a coat of tar or other protective surfacing, so is the long life of an Ingot Iron product further extended by a good zinc or enamel coating.



Enameling Armco Ingot Iron Sheets in a large manufacturing Plant.

The Laboratories and Test Yard at the Mill

NOT content with the testimony that comes from all parts of the world and from widely differing industries regarding the rust-resisting qualities of ARMCO Ingot Iron, the manufacturers—The American Rolling Mill Co.—maintain at the plant at Middletown, Ohio, a laboratory housed in a building of its own and provided with the most modern equipment for testing materials. The laboratory and the test yard operated in connection with it for the purpose of conducting tests under actual service conditions are under the supervision of expert metallurgists, assisted by a corps of competent chemists and microscopists.

The Laboratory and Administration Building. American Rolling Mill Co., Middletown, Ohio.

A corner in the Laboratory. American Rolling Mill Co., Middletown, Ohio.

The laboratory above referred to is used exclusively for investigational work, the regular routine chemical analysis of raw materials and furnace products being taken care of by two other well equipped laboratories located adjacent to the open hearth furnaces. As indicative of the care with which the output of the furnaces is checked it may be mentioned here that before the furnaces are tapped repeated samples are taken from each batch of melted metal (or "heat" as it is called) and analyzed to make sure that the impurities do not exceed 16 one-hundredths of one per cent. Although many thousands of tons of ARMCO Ingot

Iron are made annually the variation in chemical composition has been found to be less than two-hundredths of one per cent in the average of material made from year to year. The very small percentage of impurities not eliminated in the process of manufacture is also found to be remarkably uniform in character and amount, this indicating that the ARMCO processes have been thoroughly standardized, resulting in a product that is always the same wherever and whenever it is purchased.

This is in striking contrast to results obtained in the manufacture of some of the sheet iron and steel said to be "just as good as ARMCO Ingot Iron." From time to time The American Rolling Mill Co. subjects competitive sheets to the same analytical investigations that its own product undergoes. Wide variations in chemical composition are found to exist in these competitive sheets. For instance, the amount of carbon has been found to vary from .04 to .235, a difference of nearly 600 per cent. The phosphorus content has been found to vary 500 per cent, while the copper content is sometimes .02 and sometimes .509, a difference of 2,500 per cent!

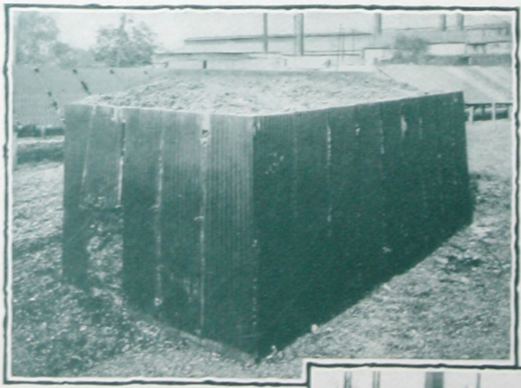
The laboratories and test yard maintained by The American Rolling Mill Company and the services of their metallurgical experts are used not only to study the Mill's own problems but the problems of the Mill's customers as well. Here have been conducted many investigations that have benefited customers not only in a monetary way, but in improving the quality of their products or simplifying some troublesome detail of manufacture. In the museum that occupies the basement floor of the main

Taking sample of metal from furnace for analysis. Every heat must have the Laboratory's O. K. before the furnace is tapped.

laboratory are numerous interesting exhibits illustrating the very practical nature of the aid extended by the Mill to its customers.

In the test yard there are exposed to the elements, and to various other corrosive influences, thousands of sheets of steel and iron of different makes, including ARMCO Products. Atmospheric tests which consist in exposing the sheets to the weather on wooden frames are sometimes continued for several years; but quicker results are obtained in some of the accelerated tests. These tests are made only with the idea of indicating what results may be expected from such sheets in actual service under identical conditions.

For the purpose of observing the effect produced by running water on sheets of various makes, a canal that flows through Middletown is utilized, the sheets being suspended from a timber support adjacent to a spill-way so as to be kept in constant contact with the water. The destructive effects on iron and steel produced by coal gas, soot and other products of combustion are



The Manure test. Steel sheets have rusted away. ARMCO Ingot Iron Sheets still in good condition.

The Spray Test. ARMCO Ingot Iron sheets suspended from stringer of bridge in front of spill-way so that sheets are continually wetted by the spray.

studied by means of specially constructed stoves, the body of the stove itself and the various lengths of pipe being made of the several kinds of iron and steel that it is desired to test. Many other methods of determining the rust-resisting qualities and other characteristics of sheet iron and steel of various makes are being constantly devised at The American Rolling Mill, the object being in all cases to subject the materials being tested to conditions as nearly as possible like those encountered in actual services and to expose each sheet tested to exactly the same influences and for the same length of time.

The results of these numberless tests extending (many of them) over a long period of years has been to confirm the opinion now held by a majority of leading metallurgists, namely, that to insure long continued service under any of the normal destructive influences to which products of iron or steel are commonly subjected, the two principal factors are, first, the nearest possible approach to absolute purity of chemical content, and, second, the highest attainable uniformity in texture. These two factors are found to a greater degree in ARMCO Ingot Iron than in any other iron or steel now manufactured in commercial quantities.

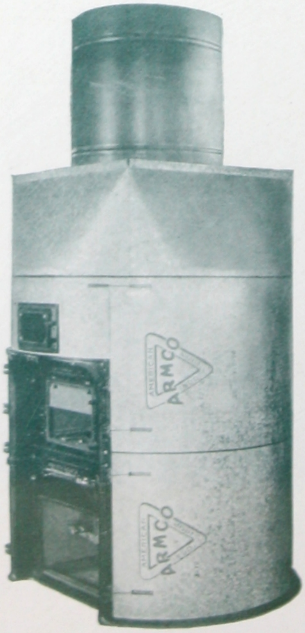
The attempts of other manufacturers to produce a metal possessing all the merits of ARMCO Ingot Iron have been equalled, if not exceeded, by The American Rolling Mill's attempt to improve on its own product. Many different alloys have been devised by the Mill experts in this endeavor but none of them on test were found to possess to the same extent the desirable qualities that have made ARMCO Ingot Iron famous the world over.

Two views of the Test Yard at Middletown, Ohio. Here Armco and competitive sheets are exposed in the open for several years and their condition noted from time to time. The view at the left shows the sheets covered with snow.

Industries in Which Armco Ingot Iron is Used

THE most impressive testimony to the rust-resisting qualities of ARMCO Ingot Iron is found in the large number of manufacturers, in various lines of industry, who employ this metal in the making of their own products. Large industrial plants using hundreds of thousands of dollars worth of sheet metal a year do not lightly abandon a metal they have been in the habit of using and adopt a new one without subjecting the new metal to the most searching tests—they have too much at stake to take chances. Within the past ten or twelve years more than 200 manufacturing concerns have investigated the claims made for ARMCO Ingot Iron, have tested it, experimented with it, and have finally adopted it as their standard material.

Let us take, to begin with, the subject of stoves and furnaces. Water or steam is always present when stoves or furnaces are in use; oxygen is present in the air, and the coal used for fuel contains sulphur. Here, then, we have the three elements necessary to form sulphuric acid (H_2SO_4) together with heat which is favorable to chemical combination. Wherever coal (or coal gas) is burned in the presence of moisture and air, sulphuric acid is formed and it was this that nearly ruined the stove industry when manufacturers first began to build stoves and ranges of sheet metal, for they used steel sheets and the sulphuric acid made short work of them. The old-fashioned cast iron range had not suffered so much because of an impervious skin that is formed on the surface of cast iron in the process of molding, but in spite of its heavy weight, its greater cost, and its clumsy appearance, manufacturers were seriously considering returning to the cast iron range when ARMCO Ingot Iron stepped in and saved the situation. Here is a letter from a stove manufacturer addressed some years ago to the manufacturers of ARMCO Ingot Iron.



SOME PRODUCTS MADE OF ARMCO INGOT IRON

- Anchors
- Automatic Hog Feeders
- Automatic Unloaders
- Automobile Licenses
- Barrels
- Bedside Tables
- Bins and Cribs
- Boilers
- Bond Wires
- Bucket Pumps
- Burners
- Cafeteria Equipment
- Carbide Generators
- Carrier Tubs
- Cisterns
- Coal and Gasoline Ranges
- Concrete Mixers
- Conductor Pipes
- Combination Heaters
- Compartment Boxes
- Culverts
- Desks
- Dishwashers
- Doors and Partitions
- Down Spouts
- Drain Outlets
- Electric Radiant Heaters
- Electric Washers
- Electric Wringers
- Farm Engines
- Fencing
- Fire Escapes
- Fire Extinguishers
- Flumes
- Fountains
- Freight Cars
- Furnaces
- Gas Floor Heaters
- Gas Holders
- Gas Machines
- Gas Ranges
- Gasoline Storage Tanks
- Gasoline Service Tanks
- Gas Wells
- Gluten Developers
- Grave Vaults
- Gutters
- Heater Systems
- Herringbone Lath
- Hog Waterers
- Ice Cream Containers
- Iceless Coolers
- Kitchen Dressers
- Kitchen Sinks
- Kitchen Tables
- Lamps
- Lamp Oil Pots
- Lighting Fixtures
- Lighting Machines
- Lightning Protectors
- Lightning Rods
- Manifolds
- Marine Engines
- Mechanical Milkers
- Metal Caskets
- Metal Doors
- Metal Screens
- Metal Tubs
- Milking Machines
- Motor Car Heaters
- Motor Starting Switches
- Oil Condensers
- Oil Drafts
- Oil Heaters
- Pipe
- Playground Slides
- Photographic Trays
- Porcelain Enameled Signs
- Porcelain Ranges
- Porcelain Refrigerators
- Radiators
- Rail Braces
- Ranges
- Reflectors
- Roofing
- Rotary Scrubbers
- Safety Treads
- Scalding Vats
- Seed Bins
- Sewage Tanks
- Siding
- Silos
- Silo Door Frames
- Soft Drink Coolers
- Steam Engines
- Sterilizers
- Stoves
- Stranded Wire
- Street Signs
- Submarine Motors
- Table Tops
- Tanks
- Telephone and Telegraph Wires
- Thermometers
- Toilet Flush Tanks
- Transformer Tanks
- Tubes
- Ventilators
- Washers
- Warm Air Heaters
- Watering Fountains
- Water Meters
- Water Tanks
- Water Wheels
- Well Casings
- Welding Wires
- Windows

"This company has been using ARMCO Ingot Iron exclusively in our range and heater bodies for the past six years. At the time we adopted its use, the steel range trade was in a badly demoralized condition and it was freely predicted by both dealers and manufacturers that the cast iron stove would soon supersede the sheet metal stove and that it would be but a short while until what is commonly termed a steel range would be but a memory. In fact, one of the foremost manufacturers of stoves advertised the fact broadcast to the world that the steel range was a failure, due to the fact that the body would rust out in a short time, and that they would no longer recommend them; in fact, would discourage their sale and endeavor to turn the trade to their cast iron line. About the same time we began the use of ARMCO Ingot Iron sheets, thoroughly advertised its rust-resisting qualities, gave a binding guarantee with every stove, and more than doubled our business in the past five years."

Here is a paragraph from a letter from another stove manufacturer: "We attribute our success in a very large measure, to the use of pure iron sheets; in fact, we believe the influence of ARMCO Ingot Iron has gone a long way towards restoring that branch of the stove industry to the place to which it rightfully belongs."

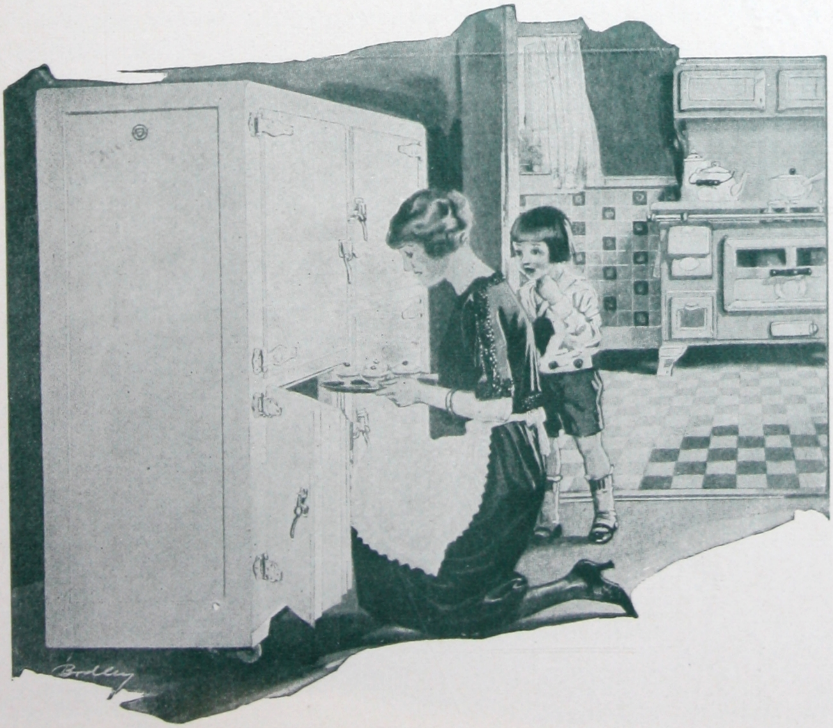
At the present time more than 50 manufacturers of coal and gas stoves and furnaces and electric ranges are using ARMCO Ingot Iron—and advertising the fact that they use it.

Among other products that are subject to corrosion from the same causes that produce rust in stoves and ranges are stove pipes and smoke stacks, range boilers, locomotive jackets, boiler tubes, stationary engine guards, coal mining machinery and gas holders. Leading manufacturers of all these products are using ARMCO Ingot Iron.

Washing machines and dish washers are liable to rust because of the continual wetting and drying they are subjected to and because of the corrosive chemicals contained in soaps and washing powders. ARMCO is represented by a number of manufacturers in these fields, including the world's largest manufacturers of equipment for steam laundries. Some 30 manufacturers of refrigerators, ice cans for refrigerating machines, milk cans, soda fountains, kitchen cabinets and enameled table tops are also large users of ARMCO Ingot Iron.

Among products subject to corrosion through exposure to the weather may be mentioned metal window frames and doors, metal shingles, ventilators, playground devices, metal garages and other portable buildings, street and road signs, farm equipment, telegraph and telephone wire and wire fencing. In all of these fields ARMCO Ingot Iron is widely used.

Other commercially pure iron products are gasoline and other storage tanks, acetylene generators, sewage disposal and other septic tanks, guy anchors, seamed and riveted pipe, and metallic caskets and grave vaults. In these various lines ARMCO Ingot Iron is used by some 30 manufacturers.

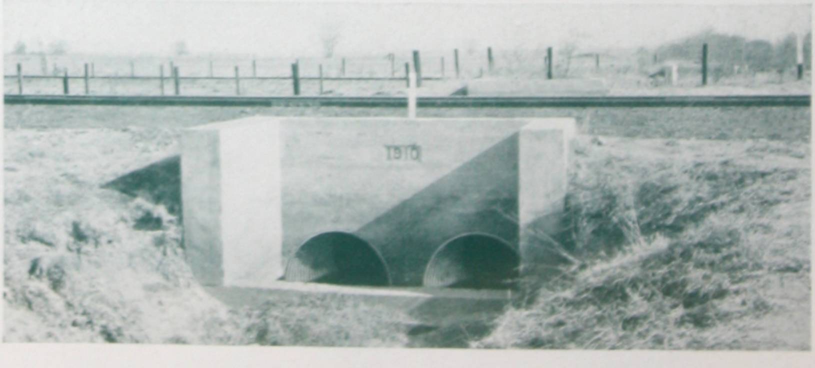


Durability of Products Made of Armco Ingot Iron

THE Century Dictionary defines DURABILITY as, "the power of lasting or continuing in the same state by resistance to causes of decay or dissolution." This power ARMCO Ingot Iron products possess to a superlative degree. This durability—this power to resist rust—is due to the high degree of iron purity in ARMCO Ingot Iron. In the chapters treating of the metallurgy of iron and steel, the causes of corrosion, and the precautions observed in the manufacture of ARMCO Ingot Iron, no proof has been given that articles made of this pure metal *do* continue in the same state under conditions of service that tend to stimulate decay and dissolution.

This proof we offer now. Let us take as our first example, the earliest ARMCO Ingot Iron culverts. To a greater extent than any other commonly used iron structure, a culvert must withstand corroding influences. It is subjected to the action of acid or alkaline soils in combination with water; the oxygen in the air; the stress of expansion and contraction due to temperature change; and the strains occasioned by shifting earth and varying loads. Yet, ARMCO Culverts, buried in soils of widely different characteristics, subjected to freezing and thawing, rains and snows and tremendous loads, are practically as good today as when they were first installed more than ten years ago.

Know that not "just a few" ARMCO Ingot Iron Culverts have endured in this fashion.



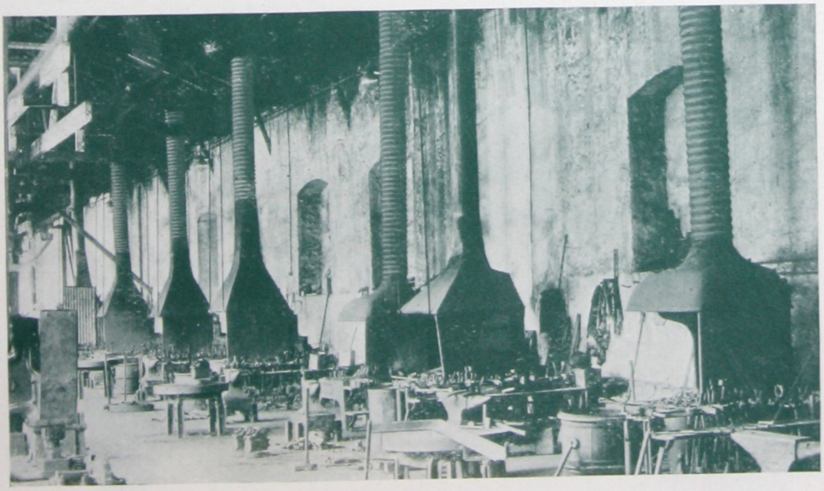
A STRIKING INDICATION OF PERMANENCE

The engineer, who inscribed the date of installation—1910—in the end wall of this Armco Ingot Iron Culvert, showed his faith in the permanence of this construction. Today, after 13 years' continuous service under severe corroding conditions, this installation shows practically no sign of deterioration.

Whether installed 5 years or 14 years they are nearly *all* just as serviceable as they were when the last shovelful of earth was thrown into the fill. Here is evidence, not alone of durability, but of uniformity—of unvarying purity and high quality. But let us cite some examples of other ARMCO Ingot Iron products. If the 15 years that ARMCO Ingot Iron has been in general use is a time too short to judge of the life of a culvert, you can easily see that it is far too short to judge of the life of most other ARMCO products. So we must resort to especially severe conditions of service where chemical action speeds up corrosion until no metal can long endure. Under such conditions it is possible to compare the duration of ARMCO Ingot Iron with other materials and judge of its greater resistance.

ARMCO CULVERTS RESIST RUST

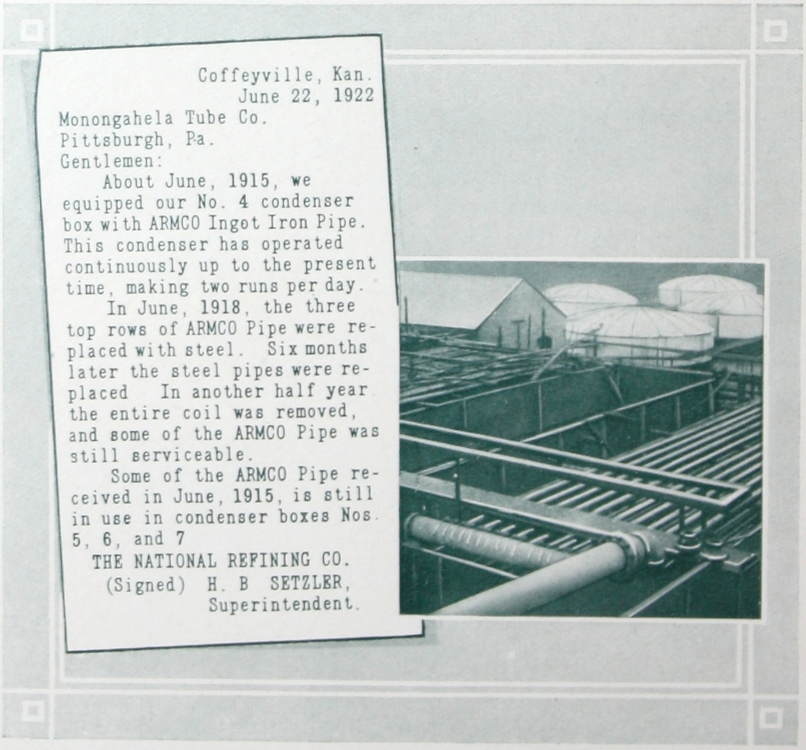
Installed in 1910 and in first-class condition after weathering the storms of Northern Michigan for over 13 years.



10 YEARS AS FUME STACKS

ARMCO Ingot Iron Pipes conveying fumes from forges in shops of City of Santos Improvement Co. Steel lasted six months in this service.

The following letter from the National Refining Co. tells a remarkable story of economy that can be duplicated in many other industries. In the condenser box mentioned, hot petroleum vapor from the crude stills is chilled in the coils of condenser pipe. *Cold water* is outside the pipe—*hot petroleum products* within. The temperature is constantly shifting over a wide range, especially in the upper three rows of pipe, for the upper rows receive the hot gases just as they come from the still. Under these severe conditions, ARMCO Ingot Iron Pipe proved that it will outlast *six separate installations of steel piping*.



Coffeyville, Kan.
June 22, 1922

Monongahela Tube Co.
Pittsburgh, Pa.

Gentlemen:

About June, 1915, we equipped our No. 4 condenser box with ARMCO Ingot Iron Pipe. This condenser has operated continuously up to the present time, making two runs per day.

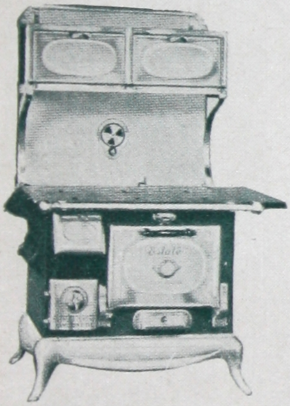
In June, 1918, the three top rows of ARMCO Pipe were replaced with steel. Six months later the steel pipes were replaced In another half year the entire coil was removed, and some of the ARMCO Pipe was still serviceable.

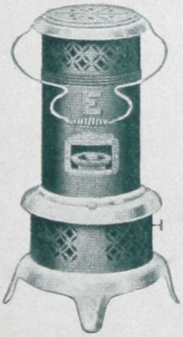
Some of the ARMCO Pipe received in June, 1915, is still in use in condenser boxes Nos. 5, 6, and 7

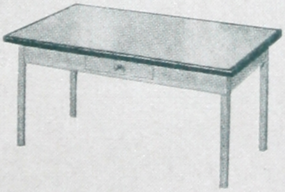
THE NATIONAL REFINING CO.
(Signed) H. B SETZLER,
Superintendent.

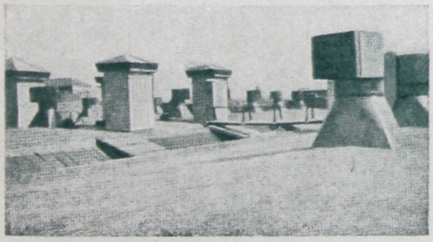
Many other similar instances prove the superlative durability of ARMCO Ingot Iron. So conclusive and convincing are these tests that they have led to some interesting developments in the use of this lasting metal in the manufacture of metal products and in structural work, as the illustrations on these pages will show.

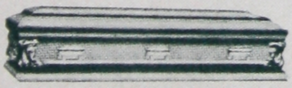
Products Using Armco Ingot Iron



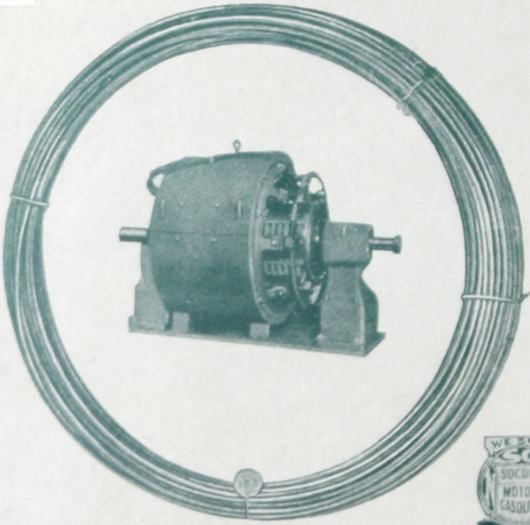


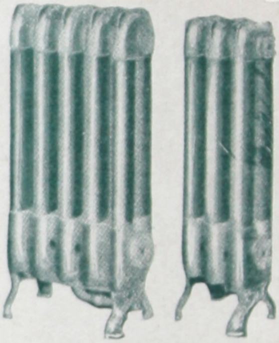


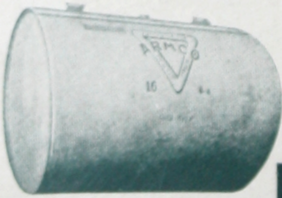


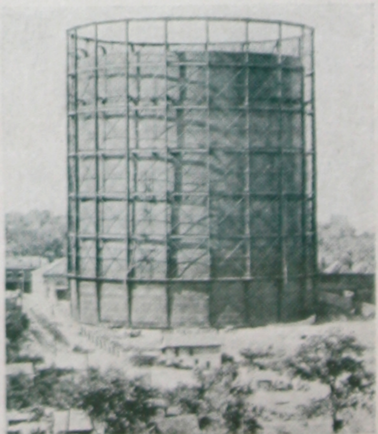


Products Using Armco Ingot Iron









Some Nationally Known Installations of Armco Ingot Iron

When an architect, engineer or contractor specifies a metal for important building or industrial projects, he does so only after the most careful investigation of its merits. The architect, for example, who designs a monumental structure like the Woolworth Building, or the huge Wilson Line Docks, demands above all else that the materials used represent the last word in permanence. The enormous investment necessary in building such structures cannot be jeopardized by the use of even slightly inferior materials, merely to effect a temporary saving. It is interesting to note that tons of ARMCO Ingot Iron have been used in construction that is designed to last for scores of years—perhaps centuries. Such faith in a metal on the part of men who know materials, and who have given ARMCO Ingot Iron close investigation, is still another convincing proof of its durability.

So well has ARMCO Ingot Iron proved its worth that it is now specified where ordinary iron or steel would not be considered. Each year sees hundreds of thousands of tons of this better material being used for new construction and the replacement of quick rusting metal—cutting down the world's great waste from corrosion.

LAUNDRY OF HOTEL PENNSYLVANIA

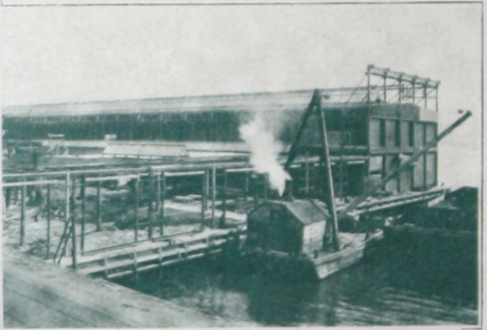
Cascade Washers of American Laundry Machinery Co. made of ARMCO Ingot Iron.

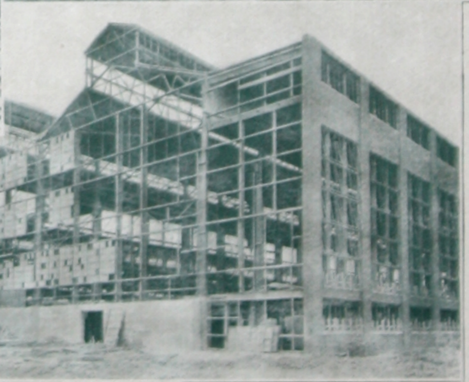
THE WOOLWORTH BUILDING

Herringbone Lath of Armco Ingot Iron is used in this famous structure.

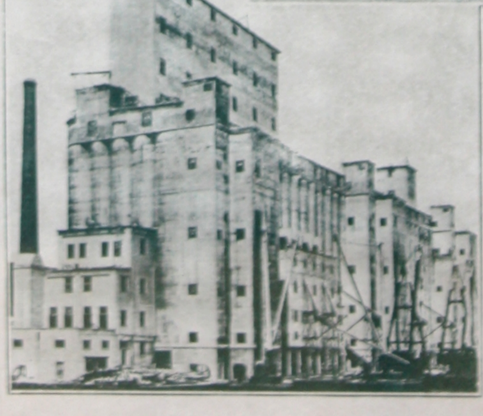
NEAR SALT SEA AIR

Great Wilson Line Pier, with 140 tons of ARMCO Ingot Iron used in roofing and siding.





ABOVE: *New plant of U. S. Sheet and Window Glass Co. Over 5 miles of ARMCO Ingot Iron gutters.*

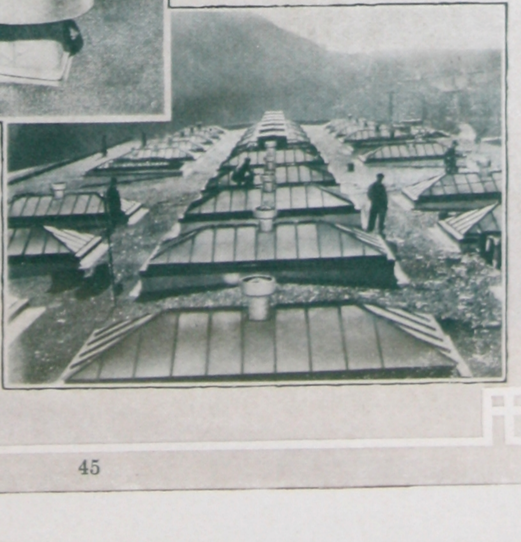


LEFT: *New York State Grain Elevator at Gowanus Bay; 40 tons of ARMCO Ingot Iron used for roofing and flashing.*

N. Y. MUNICIPAL BUILDING
Herringbone Metal Lath of ARMCO Ingot Iron.

HIBERNIA NATIONAL BANK
of New Orleans. Windows, skylights and all exposed sheet metal of ARMCO Ingot Iron.

LEFT: *Chippewa Falls Power Plant. All ventilators of ARMCO Ingot Iron.*



RIGHT: *Where smoke fumes blow. C. B. & Q. R. R. Machine Shops, using over 10 tons of ARMCO Ingot Iron for skylights and ventilators.*

The Armco Trademark and Why It Should Be Looked For

TRADE MARK
ARMCO
REG. U.S. PAT. OFF.
Ingot Iron

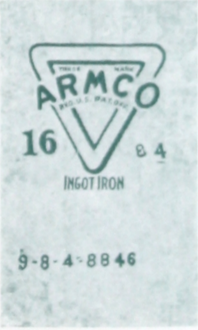
The Armco Trade Mark—an assurance of quality and solid worth.

BY appearance alone sheet iron cannot be distinguished from sheet steel even before galvanizing, except by use of a microscope. Imagine, then, how utterly impossible it is to tell one from the other when both are clad in protective coats of zinc identical in appearance—though not always alike in quality and quantity.

In the olden days of jousts and tournaments, when knights entered the lists clad in coats of mail and with visors closed, it would have been impossible to tell one from the other except for one thing—each knight bore emblazoned on his shield a device that was as familiar to the spectators as the knight's own countenance. This was his coat of arms, handed down from generation to generation, and defended even to the death.

Modern manufactured products of merit that compete with one another in the lists of trade bear a device that we call a trademark, in order that friends and foes alike may know them, and just as the laws of chivalry confined to the particular knight who was entitled to it a certain coat of arms and forbade its use by others, so our modern laws protect a manufacturer in the use of his trademark, not for the manufacturer's sake alone, but in order that purchasers who desire a particular product may not be misled into buying another that resembles it in appearance. Every sheet of galvanized ARMCO Ingot Iron is trademarked with the blue ARMCO triangle. In addition it carries its history with it, the heat number, date, gauge, etc., as indicated in the illustration on the opposite page.

These distinguishing marks attach a *personal* responsibility for each operation of manufacture, which is shouldered by each workman at the American Rolling Mill who contributes to the making of the sheet. Only in this way can the high standard of excellence be maintained.

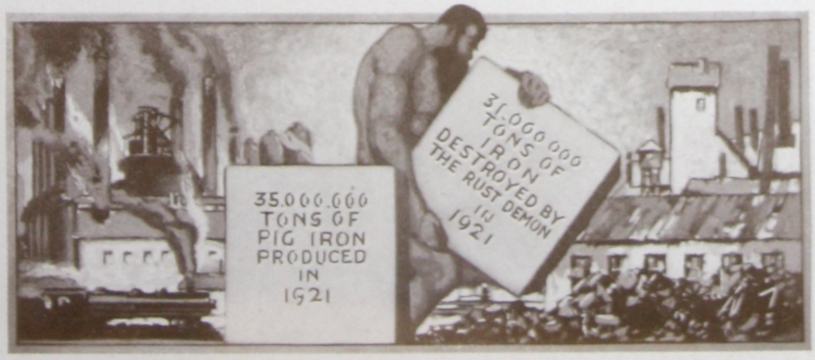


The distinctive marking on each sheet of ARMCO Ingot Iron.

Manufacturers of scores of articles, as we have seen, use ARMCO Ingot Iron. Most of their finished products carry the blue and gold ARMCO label, here illustrated. Salespeople are now familiar with this label and employ it as one of their best selling points.

Through the pages of this book we have seen that ARMCO Ingot Iron, though made by modern methods and employing the highest art of our later day progress, is virtually the counterpart of the irons of the past, so famous for their durability. And here at the close it is important to remember that painstaking *care in manufacture* and rigid *adherence* to high standards of purity and uniformity play as important a part in the making of ARMCO Ingot Iron—the purest commercial iron made—as do the new and improved mechanical processes that have made this iron possible.

How manufacturers mark their products made of ARMCO Ingot Iron.


35.000.000 TONS OF PIG IRON PRODUCED IN 1921
31.000.000 TONS OF IRON DESTROYED BY THE RUST DEMON IN 1921

A striking graphic argument for PURE iron. The rust demon carried away in 1921 a tonnage of wasted metal nearly equal to the TOTAL quantity produced in that year.—Figures from West Scotland Iron and Steel Institute (Iron Age, Jan. 24, 1924.)

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